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Extended essay cover

Diploma Programme subject in which this extended essay is registered: World Studies

(For an extended essay in the area of languages, state the language and whether it is group 1 or group 2.)

Title of the extended essay: The Effects of Modern Agricultural Practices on
the Colony Collapse Disorder of Honeybees. (A Case Study in the Swiss
catchment Area of Lake Geneva).

Candidate's declaration

This declaration must be signed by the candidate; otherwise a grade may not be issued.

The extended essay I am submitting is my own work (apart from guidance allowed by the International Baccalaureate).

I have acknowledged each use of the words, graphics or ideas of another person, whether written, oral or visual.

I am aware that the word limit for all extended essays is 4000 words and that examiners are not required to read beyond this limit.

This is the final version of my extended essay.

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Please comment, as appropriate, on the candidate's performance, the context in which the candidate undertook the research for the extended essay, any difficulties encountered and how these were overcome (see page 13 of the extended essay guide). The concluding interview (viva voce) may provide useful information. These comments can help the examiner award a level for criterion K (holistic judgment). Do not comment on any adverse personal circumstances that may have affected the candidate. If the amount of time spent with the candidate was zero, you must explain this, in particular how it was then possible to authenticate the essay as the candidate's own work. You may attach an additional sheet if there is insufficient space here.

*worked very independently on her essay,
requiring little guidance from me.*

*On submission of her draft I queried her
thoroughly on her research and findings and
so believe this is her own work as she
demonstrated great knowledge and enthusiasm
for the subject. I also provided support in
for the structure the essay*

This declaration must be signed by the supervisor; otherwise a grade may not be issued.

I have read the final version of the extended essay that will be submitted to the examiner.

To the best of my knowledge, the extended essay is the authentic work of the candidate.

I spent 2 hours with the candidate discussing the progress of the extended essay.

Assessment form (for examiner use only)

Criteria	Achievement level		
	Examiner	maximum	Examiner
A research question	2	2	
B introduction	2	2	
C investigation	4	4	
D knowledge and understanding	3	4	
E reasoned argument	4	4	
F analysis and evaluation	4	4	
G use of subject language	3	4	
H conclusion	2	2	
I formal presentation	4	4	
J abstract	2	2	
K holistic judgment	4	4	
Total out of 36		34	

The Effects of Modern Agricultural Practices on the Colony
Collapse Disorder of Honeybees:

How have specific modern agricultural and apicultural contaminants
compromised the health of honeybee populations by causing colony
collapse disorder?

A Case Study in the Swiss Catchment Area of Lake Geneva



Candidate Number:
IB World Studies Extended Essay
May 2014, Supervisor:

Word Count: 3'987

I would like to thank _____ for taking the time
to answer the questions of my interviews. I would also like to thank my supervisor Mr.
_____ and my biology teacher Mr. _____ for all of their advice and support regarding
this essay and its content.

Abstract

Honeybee populations all around the world have been collapsing at an unprecedented rate. This sudden collapse in honeybee colonies has been named Colony Collapse Disorder, an incident characterized by a heavy (>30%) and sudden colony death.

The headlines of thousand of articles have been warning the population and governments about this ecological disaster for several years since its first official report in mid-November 2006. Yet, our governments have taken minimal actions to reduce these episodes of massive collapse.

Many individual theories try to explain this phenomenon, but the science is starting to indicate that a combination of many damaging agricultural and apicultural practices is to blame. Today, the immune system of this indispensable little insect is compromised, making it more vulnerable to many pathogens, parasites and pests.

The aim of this extended essay is to investigate how specific modern agricultural and apicultural contaminants compromised the health of honeybee populations by causing colony collapse disorder in the area of lake Lemman. I want to see if what is causing the colony collapse disorder of honeybees in my area, is also what is causing it all around the world.

To do so, I interviewed beekeepers in the area and asked them what they thought was compromising their honeybee populations. I also compared the research published by independent organizations (I.e. Greenpeace) to that published by the Swiss government.

The results indicate that agrochemicals and apicultural contaminants are in fact a major factor causing the collapse of the honeybee. Although the points of view regarding the causes of collapse seem to be divided, all of the NGO and university research points to a clear direction, one where the sub-lethal doses of pesticides and insecticides are killing the bees and destroying their populations worldwide.

Word Count: 289 words

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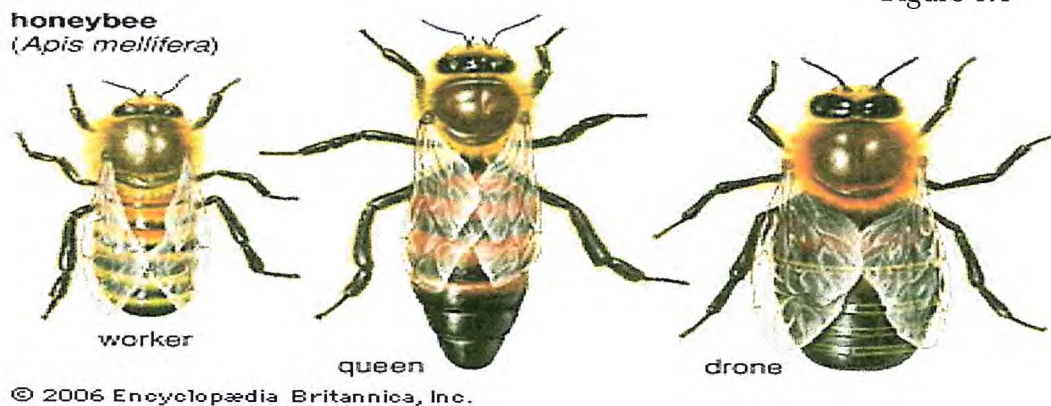
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Introduction

Originally from Europe, the honeybee (*Apis Mellifera*) has become widespread across the world since its “introduction into new continents in the 1600s”¹. Today, honeybees are globally bred to produce honey and to pollinate crops. The crucial role of honeybee and their unique pollinator abilities is responsible for one third of every bite of food we eat and for about 80% of the pollination of plants worldwide. This essay will take a multidisciplinary approach to colony collapse disorder, combining economics, chemistry, biology and environmental systems and society.

A honeybee colony is a “structure in which social bees live and rear their young”² and in which every bee works for the good of the whole. The colony is divided into three distinct groups of bees – each of which are designated specific tasks – the queen, the drones and the workers. There is only one fertile bee in the colony: the queen. Her role is to lay eggs (between 1400 and 2000 eggs per day³ – which equates to her total body mass) and ensure the positive development of her colony. She lives on average for 5 years, unlike the worker bees who do not live for more than a few months.

A honeybee colony consists of mostly infertile female worker bees, whose lives are devoted to collecting pollen and nectar for the queen and its babies. It is thanks to the demanding labor of the worker bees that flower pollination is made possible in nature and in agriculture: “worker bees are responsible for 90% of the pollination of wild plants, for at least 30% of the world’s crops pollination, and for 80% of insect pollination”⁴. Without its colony, the worker bee cannot live for more than 24 hours. Finally, the male bees (aka drones) only have the task of mating with the queen – to produce fertilized eggs – and die shortly thereafter.



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¹ Why Are Honeybees Disappearing?

<http://environment.about.com/od/biodiversityconservation/a/honeybees.htm>

² Collins English Dictionary Online – Definition of “Hive”

<http://www.collinsdictionary.com/dictionary/english/hive?showCookiePolicy=true>

³ Bee Source – How Many Eggs Can a Queen Lay?

<http://www.beesource.com/point-of-view/walt-wright/how-many-eggs-can-a-queen-lay/>

⁴ Gabriela Chavarria, “Pollinator Conservation,” Renewable Resources Journal, Winter 1999-2000.

⁵ Figure 1.1 – Honeybee Colony Population Illustration

https://www.wwt.org.uk/blog/wp-content/uploads/2012/05/Britannica.com_.jpg

The decline of our honeybee populations is not a new phenomenon. In fact, global trends in bee populations have been declining since the late 1940s. It is interesting to point out that the first modern synthetic insecticide to be developed and widely used across the United States and the world (to combat insect-borne human diseases and to control insect populations in crops), DDT (dichloro-diphenyl-trichloroethane), was introduced in the 1940s on the global market⁶. Environmental concerns and “problems related to the extensive use of DDTs began to appear in the late 1940s”⁷. DDT is now a banned insecticide and “research have shown its numerous negative impacts on honeybee populations”⁸.

In recent years however, the population of this intelligent and once robust pollinator has been declining at an unprecedented rate. Scientists across the world are still trying to solve the mystery of the massive collapse of bee populations that they have come to name: “Colony Collapse Disorder” (CCD). The first official record of CCD was recorded October 2006, where beekeepers reported colony losses ranging from 30% to 90%⁹. A decline in bee populations will also have a damaging impact on the global economy. “The global economic cost of bee decline, including lower crop yields and increased production costs, has been estimated at as high as \$5.7 billion per year”¹⁰. On average Swiss bee colonies ensure an “annual agricultural production worth of about 256 million CHF”¹¹. The global estimated value of pollination runs around “200 billion US dollars annually”¹².

“The main symptom of CCD is very low or no adult honey bees present in the hive but with a live queen and no dead honey bee bodies present. Often there is still honey in the hive, and immature bees (brood) are present. *Varroa* mites, a virus-transmitting parasite of honey bees, have frequently been found in hives hit by CCD.”¹³

Keeping bee populations safe is critical to ensure the future of our global agricultural system – ensuring that the population has access to food – and to ensure a future for our planet’s environment. The reason why bees are endangered is intricately tied to the way we’ve changed our planet.

⁶ DDT – A Brief History and Status

<http://www.epa.gov/pesticides/factsheets/chemicals/ddt-brief-history-status.htm>

⁷ DDT – A Banned Insecticide

<http://www.chem.ox.ac.uk/mom/ddt/ddt.html>

⁸ Marie Wilson, “DDT as Stomach Poisoning for Honeybees,” *Bios*, Vol. 17, No. 3

Pgs. 157 to 170, Oct. 1946 – Undergraduate Research

⁹ David N. Spires, “Honey Bees and Colony Collapse Disorder”, *Progressive Management*, May 4th 2013

¹⁰ Gabriela Chavarria, “Pollinator Conservation,” *Renewable Resources Journal*, Winter 1999-2000.

¹¹ The Economic Value of Pollination Services Provided Bees in Switzerland
Tim Besser, 2005

¹² UN Food and Agricultural Organization

http://www.nytimes.com/2013/04/30/business/global/30iht-cubecs30.html?_r=0

¹³ Honeybees and Colony Collapse Disorder

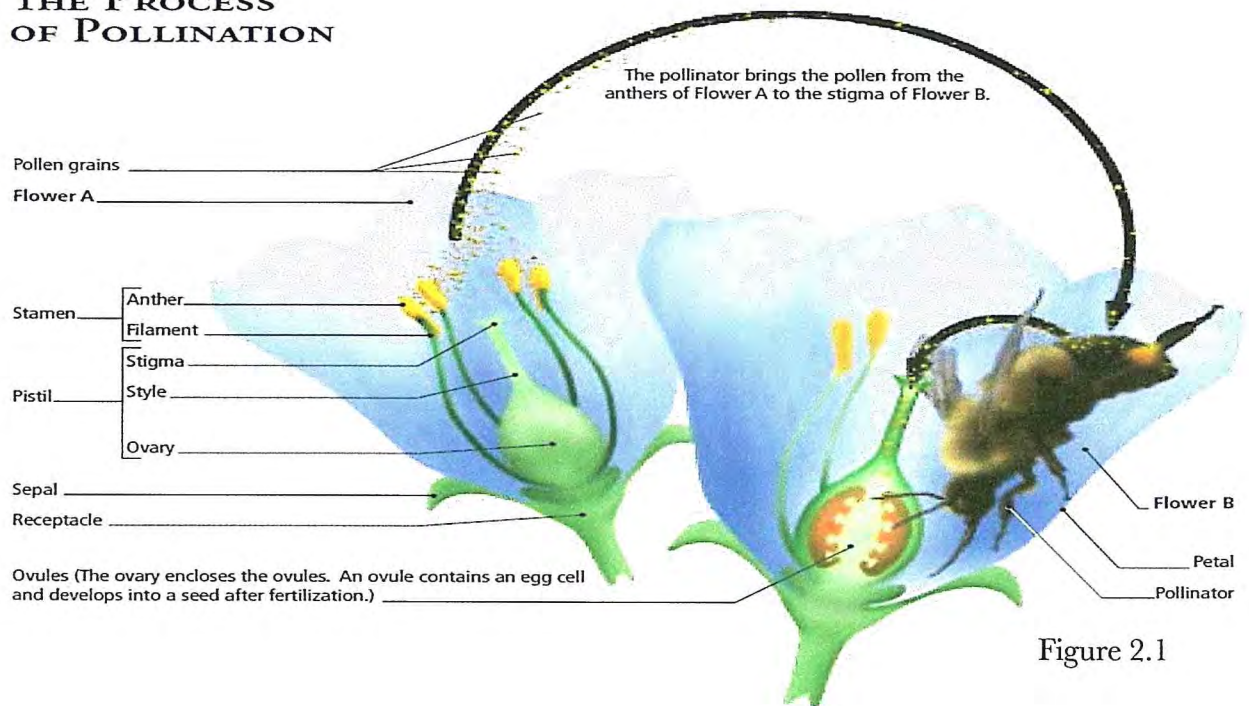
<http://www.ars.usda.gov/News/docs.htm?docid=15572>

Pollination

Pollination is the “transfer of pollen from an anther to the stigma of a flower”¹⁴.

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THE PROCESS OF POLLINATION



There are two types of pollination in nature: abiotic (where pollination is mediated without the involvement of another organism – 10%) or biotic (requires a pollinator to transfer sex cells from one plant to the next – 90%). A new type of pollination is now used in places where pollinators have gone extinct due to environmental contamination. It is called hand pollination (human pollination). This practice is costly and ineffective practice in the long run.

In insect pollination, ripe pollen from a flower's stamen attaches to an insect's/pollinator's body. The insect then flies to another flower, where it deposits pollen grains (male sex cell) on the receptive stigma (female reproductive organ of the flower). Successful pollination enables fertilization, and thus the formation of a fruit or vegetable. A bee can pollinate crops in a 78km² area around its hive.

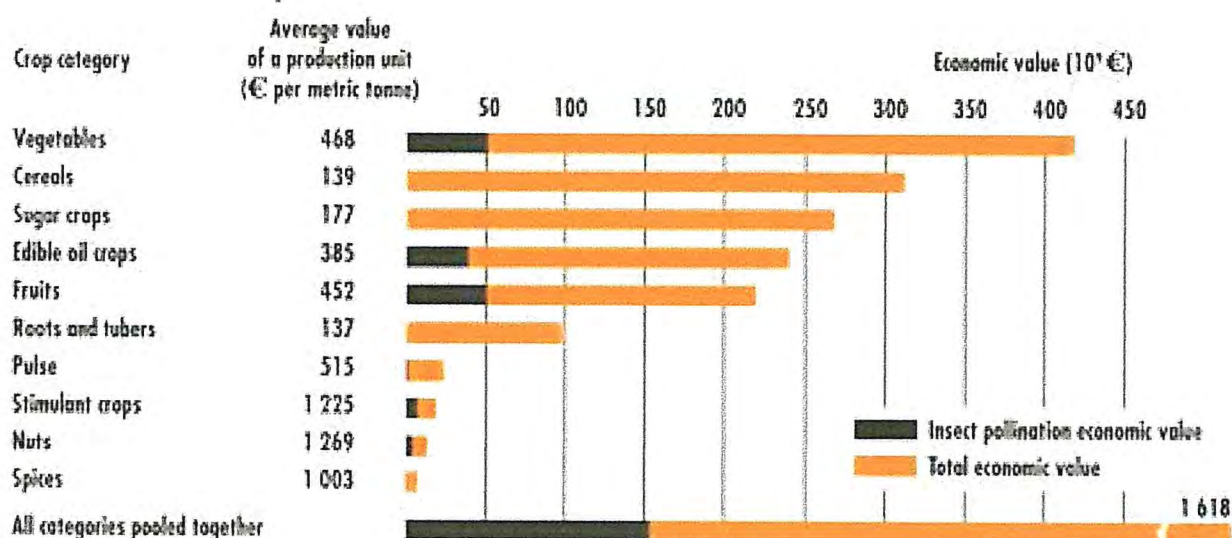
¹⁴ Benjamin Cummins, Campbell Biology, “Plant Form and Function”, Unit Six Ninth Edition, Oct. 2010

¹⁵ Figure 2.1 – The Process of Pollination

<http://cwf-fcf.org/en/discover-wildlife/resources/resource-sheets/the-science-of-pollination.html>

Honeybees are nature's most important pollinators. In fact, honeybees pollinate billions of dollars worth of food each year, which equates to approximately a third of the food we consume. In general, "the value of bee pollination in a given region is 30 to 50 times that of the honey and wax harvested"¹⁶.

Figure 1: Economic impact of insect pollination on agricultural production used directly for human food worldwide



The contribution of pollinators to the production of crops used directly for human food has been estimated at €153 billion globally, which is about 9.5% of the total value of human food production worldwide ⁶.

- ⁶ Gallai N. et al., 2009. "Economic valuation of the vulnerability of world agriculture confronted with pollinator decline". *Ecological Economics*, 68: 810-821

Due to its essential role in agriculture, pollination, a once natural process, has become completely industrialized. The little honeybee has become a victim of this industrialization in many respects, including by being continuously exposed to the pesticides and chemicals used on the crops it pollinates. The honeybee works all day long to pollinate the plants that we, humans, consume on a daily basis. Yet, modern agricultural practices fail to minimize the direct and indirect harm of agro-chemicals on bees.

¹⁶ Bees and Their Role in Forest Livelihood – The Value of Bees for Crop Pollination
<ftp://ftp.fao.org/docrep/fao/012/i0842c/i0842c09.pdf>

Honeybee Colony Collapse Disorder

Colony Collapse Disorder is the name that has been given to the latest and heaviest honeybee colony die-off across the world. This condition is characterized by a sudden and heavy (>30%) colony collapse, with little adult bees present in and around the affect hive; however, the queen and a few of her young remain in the colony. On normal years, “commercial beekeepers might expect to lose 10 to 15% of their colony, but over the past five years, mortality rates for commercial operations have ranged from 30% to 90% losses”.¹⁷ There have been incidents that report that CCD can occur in a beehive in a matter of hours.

This severe collapse of the honeybee population has caused a serious shortage of pollinators in many countries, including Switzerland (“across the 20’000 apicultures in this country, more than 170’000 colonies are threatened¹⁸”), where bees are now being imported from all around the world. Although strict laws have been set in place to regulate this practice, our government is concerned by the ability of Swiss bees to pollinate a sufficient quantity of our crops¹⁹. If this problem were to occur, Switzerland would be obliged to imported larger quantities of food across its borders. “The Food imports (% merchandise imports) in Switzerland was last repoted at 5.76% in 2011, according to the World Bank report in 2012”²⁰. Although this number is low compared to some of our neighboring countries or ever compared to the Unites States (where “15 percent of the U.S. food supply, including nearly 50 percent of fresh fruit and 20 percent of fresh vegetables are imported”²¹), our food security (and thus the population’s health) on a national level cannot be guaranteed in the long run should our bee populations keep on declining.

A variety of factors are suspected to cause CCD, but experts argue that it is combination of those factors that poses a serious threat to honeybee populations worldwide.²² Farmers and beekeepers across our nations have come together to try and find a solution for the die-off of the Swiss bees and to highlight the toxicity of agro-chemicals (such as phytosanitary products – aka pesticides) on this essential pollinator²³.

¹⁷ Beepocalypse Redux

<http://science.time.com/2013/05/07/beepocalypse-redux-honey-bees-are-still-dying-and-we-still-don't-know-why.html>

¹⁸ Stratégie Pour la Promotion de l’Agriculture Suisse

<http://www.blw.admin.ch/dokumentation/00016/00261/index.html?lang=fr&msg-id=19429>

¹⁹ Importation d’Abeilles dès 2013 – Association Suisse des Vétérinaires Cantonaux

http://ge.ch/dares/SilverpeasWebFileServer/ASVC_importation_abeille_2013.pdf?ComponentId=kmelia919&SourceFile=1354107548192.pdf&MimeType=application/pdf and <http://www.sbv-usp.ch/fr/medias/communiqués-de-presse/archives-2013/100613-abeilles/>

²⁰ Food Imports in Switzerland

<http://www.tradingeconomics.com/switzerland/food-imports-percent-of-merchandise-imports-wb-data.html> and <http://www.indexmundi.com/facts/switzerland/food-imports>

²¹ Strengthening Oversight of Imported Foods

<http://www.fda.gov/ForConsumers/ConsumerUpdates/ucm362462.htm>

²² David N. Spires, “Honey Bees and Colony Collapse Disorder”, Progressive Management, May 4th 2013

²³ We Can No Longer Tolerate the Abnormal Death Rate of Bees

<http://www.sbv-usp.ch/fr/medias/communiqués-de-presse/archives-2013/100613-abeilles/>

The Causes of CCD Worldwide

The truth of the matter is that “a combination of many factors is most probably what is causing the massive colony collapses we have experienced in recent years”²⁴.

Although the validity of several these causes is still being debated, the global scientific community seems to agree that the following “list of factors”²⁵ is potentially contributing to CCD.

1. **Neonicotinoids** and other forms of **agro-chemicals**
2. **Parasites**, Mites, Pathogens and other diseases
3. **Monocultures** (these are heavily treated with agro-chemicals, including pesticides and insecticides as monocultures are very vulnerable to pests)
4. Genetically Modified Organisms (**GMOs**)
5. **Antibiotics** and **Miticides** (used in hives to treat the bees and prevent mite infestations)
6. **Migratory Beekeeping** (travelling across nations with bees carried in trucks or planes – very stressful practice causing “10% loss of bees in each trip”²⁶)
7. **Loss of Genetic Diversity** (due to the artificial insemination of queen bees)
8. Inadequate Forage and **Malnutrition** (due to monocultures and loss of plant biodiversity)
9. **Climate Change** (Global Warming causing unstable climatic conditions)
10. **Toxins in the Environment** (due to industrialization and urbanization)

After interviewing local beekeepers, I quickly realized that only a handful of these “causes” seem to be directly affecting the Lemanic honeybees (the details of which can be found in Appendix I to III). For instance, due to Switzerland’s limited size, we do not have monocultures and migratory beekeeping is rare. In addition all forms GMOs have been “banned in Switzerland from 2005 to 2013 in a public referendum”²⁷. Other of the potential causes listed above remain unmentioned and unexplored in the Swiss Lemanic Region, perhaps this is because they are not suspected of causing significant damage to the honeybees (such as malnutrition, poor forage and loss of genetic diversity).

28 This image shows a honey
dying on the ground while
the crop it was pollinating
was treated with an
organophosphate
pesticide.



²⁴ Colony Collapse Disorder
2012 Annual Progress Report
USDA – CCD Steering Committee

²⁵ Factors Listed in David N. Spires,
“Honey Bees and Colony Collapse Disorder”,
Progressive Management, May 4th 2013

²⁶ “The Vanishing of the Bees”
Documentary by George Langworthy

²⁷ What Countries Have Banned GM Crops?

<http://www.examiner.com/article/what-countries-have-banned-gmo-crops>

²⁸ Vanishing Honey Bee Image

<http://www.forbes.com/sites/jonentine/2013/04/11/science-collapse-disorder-the-real-story-behind-neonics-and-mass-bee-deaths/>

The Suspected Causes of CCD in the Area of Lake Geneva

After interviewing different beekeepers (full interview can be read in Appendix I, II and III) in the catchment region of Lake Geneva, three main factors seemed to be affecting their bee colonies:

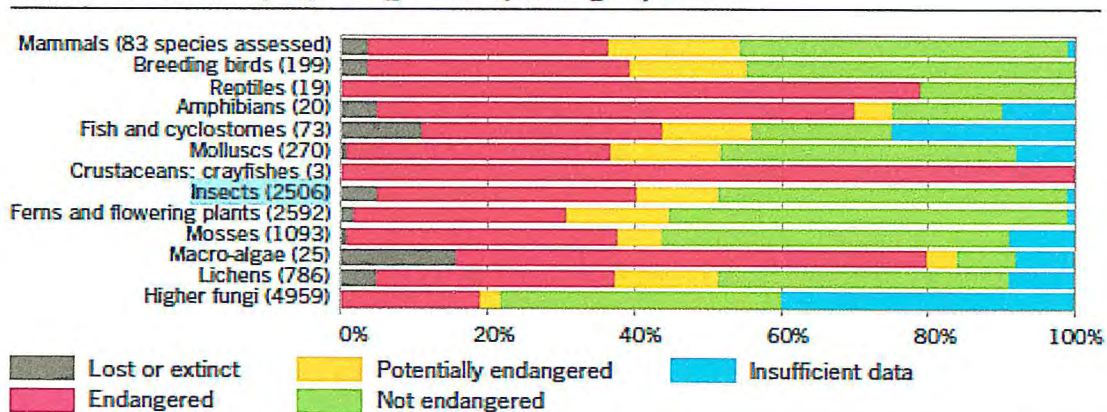
1. Neonicotinoids, Agro-chemicals and Industrialized Agriculture
2. Parasites and Mites, Specifically the Varroa Mites
3. Environmental Toxins and Climate Change

It was interesting to see that some beekeepers claimed to be affected by only one factor, while others were affected by a combination of them. All the beekeepers interviewed had varroa mites in the colonies once they had collapsed; most of them believe that the mites were not ultimately responsible for the colony's decline and that other factors – mostly the newly introduced systemic neonicotinoids pesticides – were to blame.

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Native species lost, endangered, possibly endangered or not endangered
Status 1994 to 2012, depending on the species groups

Figure 5.1



Source: Federal Office for the Environment

© FSO

Approximately 50% of native insects are endangered or potentially endangered in Switzerland. This statistic includes the honeybee. Regardless of the true cause or causes of the honeybee population decline, actions must be taken quite urgently to prevent the total collapse of these currently threatened pollinators.

²⁹ Figure 5.1 – Native Specie Loss in Switzerland

Swiss Environmental Statistics – A Brief Guide 2012

www.bfs.admin.ch/bfs/portal/en/.../publikationen.Document.162687.pdf

Neonicotinoids, Agro-chemicals and Industrialized Agriculture

Various pesticides are used all around the area of lake Geneva for different crops. Below is a map, showing the distribution and total quantities of active substances applied to all the crops treated in the Swiss part of the catchment area of Lake Geneva:

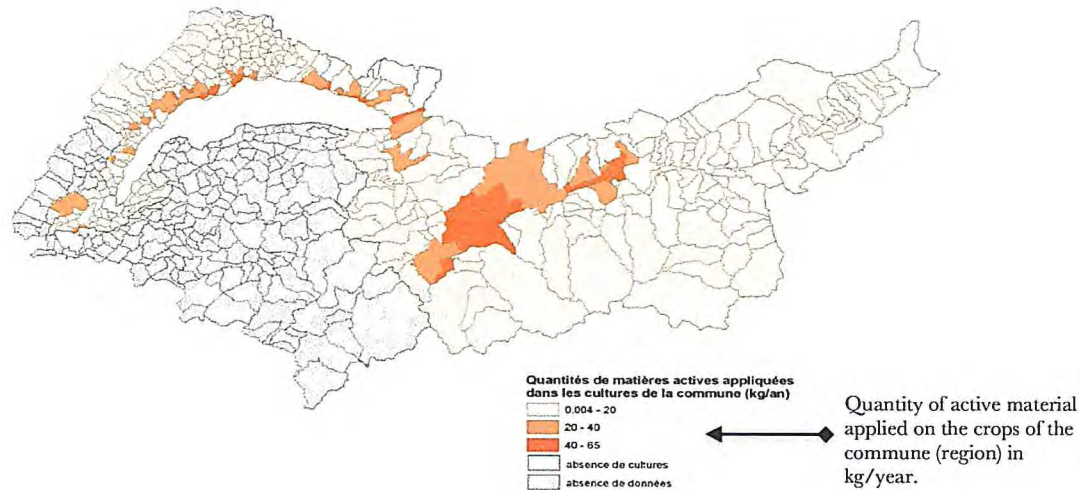


Figure 2 : Quantités totales de matières actives appliquées sur l'ensemble des cultures traitées sur la partie suisse du bassin lémanique en $\text{kg}\cdot\text{ha}^{-1}\cdot\text{an}^{-1}$

Figure 2 : Total quantities of active substances applied to all the crops treated in the Swiss part of the catchment area of Lake Geneva in $\text{kg}\cdot\text{ha}^{-1}\cdot\text{year}^{-1}$.

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As you can see from the figure above, the majority of the land in the region is treated with some type of pesticide (grey region = France). This does not necessarily mean that all of the pesticides used are harmful to the bees, yet it shows that any honeybee in the area will in fact be exposed – even if it might be in small doses – to pesticides. However, the map shows that the use of pesticides in the region, Switzerland “has witnessed a 40% reduction in its sales of pesticides in the last 15 years, an effort among the most successful in Europe”³¹. In addition, farmland area has decreased nationally for many years (“23.9% of the total area of Switzerland is used for agriculture”³²) and Switzerland has one of the highest shares of organic farming area in Europe (“10.6% in 2009”³³)

³⁰ Agricultural Pesticides in the Swiss Catchment Area of Lake Geneva - 2006

http://www.cipel.org/wp-content/uploads/2012/07/Camp06_15_Pesticides-agricoles-dans-le-BV.pdf

³¹ Switzerland: IP Protocols for All Major Crops

<http://www.pan-europe.info/PURSE/Switzerland.html>

³² Swiss Agriculture Statistics – 2008

www.bfs.admin.ch/bfs/.../publ.Document.104914.pdf

³³ Swiss Environmental Statistics – A Brief Guide 2012

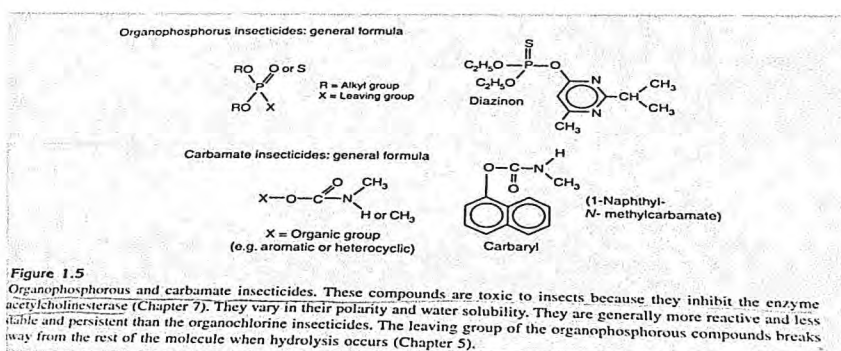
www.bfs.admin.ch/bfs/portal/en/.../publikationen.Document.162687.pdf

These statistics raise the question of whether or not agricultural chemicals are the source of honeybee colony collapse as there are less pesticides, less farming and more organic fields today than ever before in Swiss history. However, the toxicity of the agro-chemicals and phytosanitary products we use today might be much greater to the honeybee than those used in the past, at least that is what the majority of the regional beekeepers interviewed believe.

Although many more phytosanitary chemical groups of compounds can be linked to the collapse of bees, the three groups of insecticides that are primarily responsible for bee poisoning are in the “following chemical families”³⁴:

- **Organophosphates** (such as acephate, azinphos-methyl, chlorpyrifos, diazinon, dimethoate, malathion, methamidophos, and methyl parathion)
- **N-methyl Carbamates** (such as carbaryl and carbofuran)
- **Neonicotinoids** (such as clothianidin, imidacloprid, and thiamethoxam)

Interest in organophosphorous compounds (OPs) developed during the Second World War, when chemists realized that this substance acted as a nerve poison (neurotoxin) because of its ability to inhibit the enzyme acetylcholinesterase (AChE)³⁵ (whose main purpose is to carry the signals from nerve cells to muscle cells³⁶). These chemicals were therefore produced for two main uses: “as insecticides and as chemical warfare agents”³⁷. These compounds are organic esters of phosphorous acids. “Today, a large number of organophosphorous compounds are marketed as insecticides, and nearly all of them correspond to the basic formula shown in Figure 5a.1)”³⁸.



The leaving group of the organophosphorous compounds breaks away from the rest of the molecule

³⁴ “How to Reduce Bee Poisoning from Pesticides”

H. Riedl, E. Johansen, L. Brewer and J. Barbour
2006 – Oregon State University

³⁵ Ballantyne and Matts,

“Clinical Experimental Toxicology of Organophosphates and Carbamates”
Oxford – 1992

³⁶ Acetylcholinesterase – Molecule of the Month

http://www.rcsb.org/pdb/education_discussion/molecule_of_the_month/download/Acetylcholinesterase.pdf

³⁷ Ballantyne and Matts,

“Clinical Experimental Toxicology of Organophosphates and Carbamates”
Oxford – 1992

³⁸ C.H Walker, S.P Hopkin, R.M Sibly and D.B Peakall

“Principles of Ecotoxicology”

Taylor & Francis Group – 2006

The organophosphorous compounds are generally “more reactive and less stable and persistent than the organochlorine insecticides”³⁸. They tend to be “relatively short lived when free in the environment, and the environmental hazards that they present are largely, but not exclusively, associated with short term (acute) toxicity”³⁹. As with other neurotoxic pesticides, there is concern about the behavioral effect of OPs, at sublethal doses, on bees.

Organophosphate insecticides are not only used in region of Lake Geneva, but traces of several of these compounds have been detected in the honey and beeswax from the area.

Organochlorine pesticides	Honey mg/kg	Wax mg/kg	Organo-phosphorus pesticides	Honey mg/kg	Wax mg/kg	Organo-phosphorus pesticides	Honey mg/kg	Wax mg/kg
Alachlor, Aldrin	< 0.01	< 0.1	Bromophos-ethyl; -methyl	< 0.01	< 0.05	Parathion-ethyl; -methyl	< 0.01	< 0.1
Chlordan, alpha, gamma	< 0.005	< 0.05	Carbophenothion	< 0.05	< 0.1	Pirimiphos-methyl	< 0.01	< 0.05
Chlorfenson	< 0.05	< 0.1	Chlorfenvinphos	< 0.01	< 0.1	Profenofos	< 0.01	< 0.1
Dicofol, metabolite	< 0.05	< 0.1	Chlorpyrifos-ethyl; -methyl	< 0.01	< 0.05	Prothiofos	< 0.01	< 0.1
DDD, o,p; p,p	< 0.005	< 0.03	Chlorthion	< 0.05	< 0.1	Pyrazophos	< 0.01	< 0.1
DDE, o,p; p,p	< 0.005	< 0.03	Chlorthiophos	< 0.01	< 0.05	Quinalphos	< 0.01	< 0.05
DDT, o,p; p,p	< 0.01	< 0.03	Diazinon	< 0.05	< 0.1	Sulfotepp	< 0.01	< 0.05
Dieldrin	< 0.02	< 0.05	Dichlorfenthion	< 0.01	< 0.05	Terbufos	< 0.01	< 0.05
Dichlobenil	< 0.02	< 0.1	Dichlorvos	< 0.03	< 0.1	Tetrachlorvinphos	< 0.01	< 0.05
Endosulfan, alpha; beta; -sulfate	< 0.01	< 0.1	Dicrotophos	< 0.05	< 0.05			
Endrin	< 0.05	< 0.1	Dioxathion	< 0.1	< 0.2			
HCB	< 0.005	< 0.05	Ethion	< 0.01	< 0.05	Fungicides		
HCH, alpha; beta; delta; gamma	< 0.005	< 0.03	Etrimfos	< 0.01	< 0.1	Chlorthalonil	< 0.05	
Heptachlor-epoxid	< 0.05	< 0.1	Fenclorophos	< 0.01	< 0.1	Dichlofluanid	< 0.05	
Isodrin	< 0.01	< 0.05	Fenitrothion	< 0.01	< 0.1	Pentachlorophenol	< 0.2	
Metolachlor	< 0.01	< 0.1	Fenthion	< 0.01	< 0.1	Procymidon	< 0.1	
Mirex	< 0.01	< 0.05	Jodofenphos	< 0.01	< 0.05	Iprodion	< 0.1	
PCB 28; 52; 101; 138; 180	< 0.005	< 0.05	Malathion	< 0.01	< 0.1	Vinclozolin	< 0.01	
Quintocen	< 0.01	< 0.05	Mecarbam	< 0.05	< 0.1			
Tecnacen	< 0.01	< 0.05	Methidathion	< 0.01	< 0.1			

40

This table indicates that the honeybees in Switzerland are indeed exposed to the toxic insecticide as traces of these chemicals are found in the honey and in the wax the bees produce. The long-term effect on bees of sublethal exposure to these organophosphate and organochlorine compounds has not yet determined.

³⁹ Fest, C. and Schmidt, K-J

“Chemistry of Organophosphorous Pesticides

Berlin, Springer-Verlag – 1982

⁴⁰ Pesticide Residues in Honey and Beeswax Produced in Switzerland

www.agroscope.admin.ch/imkerrei/01810/01822/index.html

N-methyl carbamates are another from of insecticide that has been developed more recently: “they are derivatives of carbamic acid”⁴¹. Like OPs, “they act as inhibitor of the enzyme acetylcholinesterase and the main hazard that they present relates to short term toxicity”⁴². Some of them act as systemic insecticides: “An insecticide that is absorbed into plant sap and is lethal to insects feeding on or within the treated plant”⁴³, which poses great risks to pollinators that feed on the nectar and carry the pollen of the treated plant.

Finally, neonicotinoids (sometimes called neonics) is another group of neurotoxic insecticides that has been introduced in the 1990s. Neonics have been at the heart of many controversies and debate for past couple of months in Switzerland and in the European Union. While thousands of beekeepers all across Europe were reporting massive honeybee colony losses after the introduction of these pesticides, the very companies that produce them and the farmers that depend on them for higher crop yield were supporting their extensive use. Yet, “a 2-year precautionary ban on these nicotine-based agro-chemicals has been set in place and will be implemented as of January of 2014 in Europe and in Switzerland”⁴⁴. Like nicotine, they can “interact with nicotinic receptors located on cholinergic synapses (“the site of functional apposition between neurons, where an impulse is transmitted from one to another, usually by a chemical neurotransmitter released by the axon terminal of the presynaptic neuron”⁴⁵) of animals”⁴⁶

These pesticides are extensively used in agriculture because they are applied directly to the seed and not sprayed over the crop, and so they are considered “less toxic for wildlife and people than organophosphates”⁴⁷. Yet, many independent studies show that these agro-chemicals have long-term sublethal effects on honeybees, causing “perturbations of the foraging patterns of honeybees (navigation and behavior), interferences with feeding behaviors and learning processes”^{48 and 49}.

⁴¹ Kuhr, R and Dorough, W
“Carbamate Insecticides”
Cleveland, OH – 1977

⁴² C.H Walker, S.P Hopkin, R.M Sibly and D.B Peakall
“Principles of Ecotoxicology”
Taylor & Francis Group – 2006

⁴³ Systemic Insecticides
http://agriculture.science-dictionary.org/Systemic_insecticide

⁴⁴ The Real Story Behind Neonics and Mass Bee Deaths
<http://www.forbes.com/sites/jonentine/2013/04/11/science-collapse-disorder-the-real-story-behind-neonics-and-mass-bee-deaths/>

⁴⁵ Medical Dictionary – Synapse
<http://medical-dictionary.thefreedictionary.com/cholinergic+synapse>

⁴⁶ C.H Walker, S.P Hopkin, R.M Sibly and D.B Peakall
“Principles of Ecotoxicology”
Taylor & Francis Group – 2006

⁴⁷ The Real Story Behind Neonics and Mass Bee Deaths
<http://www.forbes.com/sites/jonentine/2013/04/11/science-collapse-disorder-the-real-story-behind-neonics-and-mass-bee-deaths/>

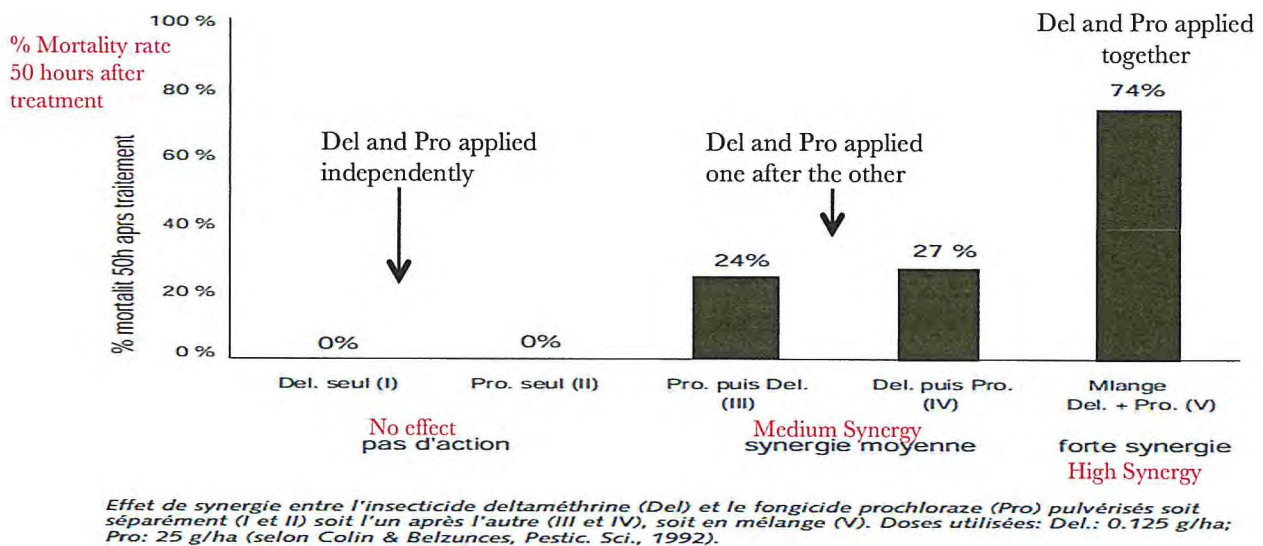
⁴⁸ Bees in Decline – Greenpeace Report
<http://www.greenpeace.org/international/Global/international/publications/agriculture/2013/BeesInDecline.pdf>

⁴⁹ Are Neonicotinoids Killing Bees? – Penn State University Study, 2012
<http://ento.psu.edu/publications/are-neonicotinoids-killing-bees>

Another important problematic that our bees are confronted with is the synergies and interactions that different agrochemicals can have. If one insecticides and fungicide is not hazardous to bees when used independently, studies have shown that when applied together on a crop, these chemicals react and form a new, highly toxic substance that can have even more devastating impacts on honeybee populations. The figure bellow is an illustration of the synergy between an insecticide (Del) and a fungicide (Pro) when strayed on a crop and its impacts on CCD.

50

Figure 5a.3



There are huge debates on the topic of agro-chemicals relating to the decline of honeybee populations in Switzerland and in the EU. With the two largest agro-chemical industries in the world located in Switzerland (Syngenta) and in Germany (Bayer), there is no doubt that the ban of potentially hazardous chemicals in EU is challenging. The multi-billion dollar generating industry, Syngenta, claims that its products – especially the most recently banned neonicotinoids – “do not affect the health of bees”⁵¹. Yet, on another part of the Syngenta website, it is written: “neonicotinoid-based pesticides can be fatal to bees, but only when mistakenly misused by farmers”⁵². If important contradiction such as these exists within the company that produces the chemicals, one can only imagine the contradictions that exist on a larger, political scale.

Yet, one question remains: does Syngenta and the other agrochemical companies that generate “billions of dollars in profit each year”⁵³ have the best interest of the bees at heart?

⁵⁰ Synergy Effect Between Insecticide (Del) and Fungicide (Pro) – Government Study 2006

<http://www.agroscope.admin.ch/imkercei/00302/index.html?lang=fr>

⁵¹ Plight of Bees – Syngenta Report

<http://www.syngenta.com/came/plightofthebees/en/Pages/home.aspx>

⁵² Plight of Bees Causes – Syngenta Report

<http://www.syngenta.com/came/plightofthebees/en/causes/Pages/causes.aspx>

⁵³ The Boon and Bane of Pesticides – Swissinfo

http://www.swissinfo.ch/eng/business/The_boon_and_bane_of_pesticides.html?cid=36216674

Parasites and Mites, Specifically the Varroa Mites

Another factor that is causing colony losses in the catchment Region of Lake Geneva are the Varroa Mites⁵⁴. The varroa mite is “the most devastating pest of western honeybees which is an ectoparasite that feed on the hemolymph of immature and adult honey bees”⁵⁵. Varroa mites attack bee colonies by transmitting various fatal diseases and infections and by eating the fertilized eggs of the queen. This parasite has been present in Switzerland for more than 25 years, yet honeybee colonies today are more susceptible to the devastating impact of the varroa mite⁵⁶. Many of the beekeepers interviewed believed that other factors (such as agrochemicals) were making the bees vulnerable by weakening their natural immune system⁵⁷. This in fact has been verified by a new study that shows that “bees that ate pollen contaminated with fungicides were three times as likely to be infected by the parasite”⁵⁸.

Chemical and natural treatments against the varroa mites are used in Switzerland. These treatments, designed to control the parasite in the colonies, seem to be ineffective for some beekeepers. In fact, some scientists even believe that the extensive use of these miticides in the hives is hazardous to bees in sublethal doses⁵⁹.



60

⁵⁴ Varroa Mite Wreaks Havoc in Swiss Bee Colonies

http://www.swissinfo.ch/eng/swiss_news/Varroa_mite_wreaks_havoc_in_Swiss_bee_colonies.html?cid=33633216

⁵⁵ Varroa Destructor Anderson and Trueman

http://entnemdept.ufl.edu/creatures/misc/bees/varroa_mite.htm

⁵⁶ Société Romande d'Apiculture, Emission de la RTS 1, 17 Avril 2012

http://www.abeilles.ch/index.php?option=com_content&view=article&id=94&Itemid=53

⁵⁷ Appendix I and II

⁵⁸ Scientists Discover What is Killing the Bees and its Worse than you Thought

<http://qz.com/107970/scientists-discover-whats-killing-the-bees-and-its-worse-than-you-thought/>

⁵⁹ The Effect of Miticides on the Reproductive Physiology of Honeybee Queens and Drones

<http://scholar.lib.vt.edu/theses/available/ctd-08162007-092313/unrestricted/lmburley.pdf>

⁶⁰ Honeybee with a Varroa Mite on its Abdomen

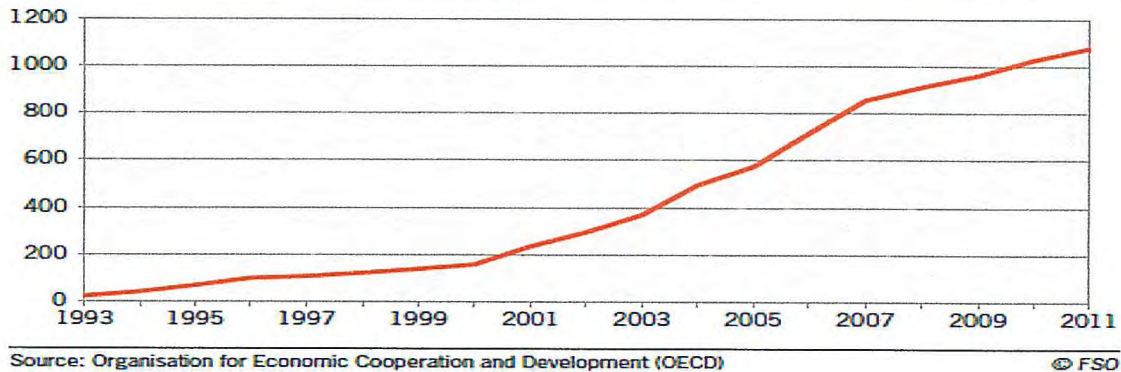
<http://www.alexanderwild.com/Insects/Stories/Honey-Bees/i-VqTmMpg/2/L/apis33-L.jpg>

Environmental Toxins and Climate Change

Environmental toxins are also considered as factors contributing to CCD.

61

Total chemicals evaluated to date by the OECD



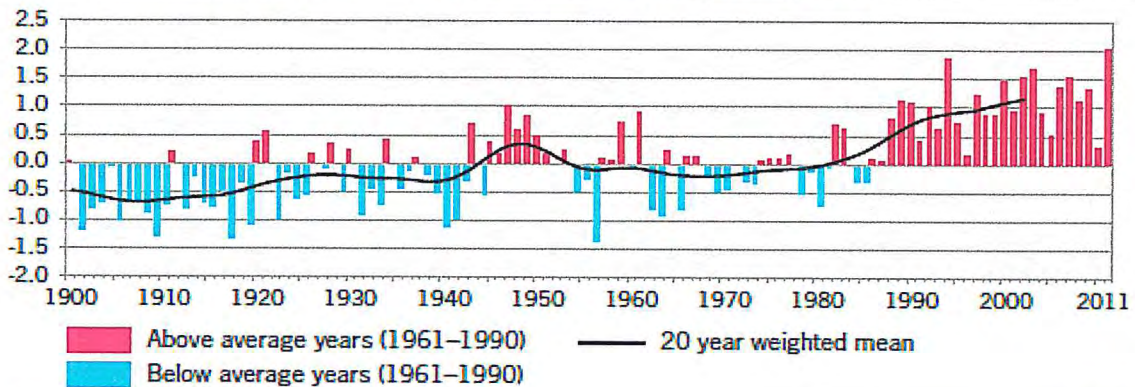
The quantity of chemicals found the Swiss environment is increasing exponentially from year to year.

In addition, the climatic conditions are also changing in Switzerland due to global warming.

62

Temperature changes

Deviation from the long-term mean (1961 to 1990), in degrees Celsius



Source: MeteoSwiss

© FSO

To this date, there is insufficient scientific data to determine whether or not environmental toxins and climate change are a factor in CCD. Nevertheless, beekeepers in the region are convinced that these two elements are contributing greater causes of overall degrading health of their honeybees⁶³ (details of which can be found in Appendix I, II and III).

⁶¹ Chemical Elements and Compounds Found in the Swiss Environment
Swiss Environmental Statistics – A Brief Guide 2012
www.bfs.admin.ch/bfs/portal/en/.../publikationen.Document.162687.pdf

⁶² Climatic Change in the Swiss Environment
Swiss Environmental Statistics – A Brief Guide 2012
www.bfs.admin.ch/bfs/portal/en/.../publikationen.Document.162687.pdf

⁶³ Appendix I, II, III

Conclusion

To conclude, from the interviews conducted for this extended essay and the research published on the topic, it is clear that a combination of modern apicultural and agricultural contaminants have compromised the health of the honeybee populations in the catchment area of Lake Geneva, causing numerous cases of CCD.

Gathering information from independent beekeepers along with research from NGOs and universities, it is clear that such contaminants have a major role in CCD. Yet, all Swiss government funded research available to the public did not even acknowledge these chemicals as a potential threat to the bees. Rather, the published studies discuss the effect of colder winters and parasites on the bees, and conclude that those factors were causing the collapses. Such studies made me question who funded them. After calling the Swiss National Science Foundation and other establishments involved with the studies, it was impossible to obtain a clear answer. Could it be that the very companies producing the agro-chemicals are funding the research that clears their names? Regardless of whether or not this could be true, the government research was not at all an accurate description of the causes of CCD.

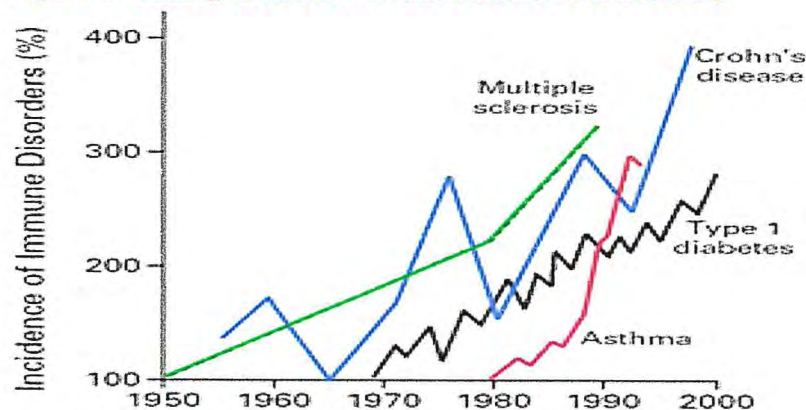
Furthermore, the President of the beekeeper association in the Region of Lake Geneva (Michael Roth) also declined that agrochemicals had any effects on the bees. Yet, all of the independent beekeepers that I interviewed (all members of his association) claimed otherwise, confirming that it was only after new pesticides were introduced in their respective regions that their bees started to die (Appendix I and III).

I think that there are many disagreements on this subject, as it is not yet fully understood. In addition, some of the research designed to explain it is bias and perhaps even unreliable (government funded).

Bees are one of the best indicators of environmental health. If the bees are dying, then it is clear that our environment is also in danger. What many fail to understand is that the problem with the vanishing bees is not only going to affect pollination (and thus our food supply), but it is also warning us that destructive diseases (like those affecting the honeybees) are to come will ultimately affect our own specie.

In recent years, autoimmune disorders have been rising exponentially. Lupus, Addison's disease and Alzheimer's are just a few examples of the common incurable disorders that so many of us are affected by today. It is interesting to see that the current state of the immune system of honeybee populations is in a way mirroring our own.

Figure 1: Rising Incidence of Autoimmune Disorders



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Another frightening fact is that honeybees have already been decimated in some regions of the world due to extensive agro-chemical and chemical contamination. A region in southwest China can no longer rely on the valuable pollinator, as its entire population is extinct. Pollination is now performed by hand by hundreds of Chinese laborers, and as one can imagine this artificial hand pollination is nowhere nearly as effected as that provided for free by the bees⁶⁵.

In addition, universities are starting to develop robotic pollinator prototypes as they are foreseeing a large demand for such products once the bees have vanished. Harvard's School of Engineering and Applied Science in the US has created what they call the "Robobee" and they have received a \$10 million grant from the National Science Foundation for its development⁶⁶. I think that such a path is a very dangerous one to following as instead of tackling the present issue of environmental degradation and solving it for the good of humanity, we are concentrating on finding unnatural solutions to solve a problem that was created using unnatural substances.

"We cannot solve our problems with the same thinking we used when we created them." - Albert Einstein

⁶⁴ Autoimmune Diseases: Modern Epidemic?

<http://alcatsandiego.com/autoimmune-disease/>

⁶⁵ China Apple Farmers Forced to do Bee's Work

<http://chinadigitaltimes.net/2012/10/chinas-apple-farmers-forced-to-do-bees-work/>

⁶⁶ Robobee - Harvard University

<http://robobees.seas.harvard.edu>

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Appendix I

In this interview, Barbara Vuille explains her experience with honeybees and their collapse in recent year. This Swiss beekeeper has been raising bees for their honey for 15 years now and has 3 hives in Geneva and 2 in nearby region in the Alpes. Only recently has she experience severe colony loses. The following interview has been translated from its original language – French.

Name:
Barbara Vuille
Beekeeper in the Region of Lake
Geneva

Contact Information:
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1203 Genève
022 340 10 39

“I have had honeybee hives for 15 year now and until recently, I never had nay problem with their health. 2 years ago, however, I had a massive colony collapse, where 100% of my bees died. In August, after a long and productive spring & summer, I prepared my bees for winter by feeding them and by treating the hives against the varroa mites, as I do every single year. By that time, their population was plentiful and healthy. A couple of months later, I wanted to go check on my hives to see how my honeybees were doing. It was a warm month of October, so I was surprised when I didn’t see any honeybees flying around the first hive. As I approached to hive to remove its top, I released that it was completely empty. There were no bees, no food and no dead insects in or around the hive. I didn’t know where they gone. The two other hives were healthy and had plenty of food. In fact they had taken the food from the dead colony once the bees were no longer there to defend it from invaders. A couple of months later, I went to check on the other 2 hives and was horrified to discover they too were now dead. Only a couple of young bees remained in the colonies along with the queen and all the food. I literally got onto my feet and hands and desperately tried to find the dead bees. Yet, the number I found was not nearly enough to explain where the others had vanished. In all my years of beekeeping, I had never experienced such a thing. All of my Geneva colonies had died in a matter of months.”

“So what do you think could have cause these collapses?”

“Two years ago, the farm next to my hives starting using a new type of seed for its sunflowers crop. This seed was treated with neonicotinoid pesticides. In addition, another neighboring field was growing sugar beets, treated with Gaucho, another systemic pesticide. I was hearing reports of colonies devastated by the varroa mite, and even tough I did find a couple mites in the dead colonies, I know that this was not what killed my bees. So, I had the honey produced from my bees analyzed, and as I expected, residues of both chemicals were present in it. I’m convinced that these chemicals are fatal to bees, especially since they can interact once in the hive or on the bee. I mean, before they were used in the agricultural lands around the hives, I never had a problem, even if the varroa mites were present at times. I have 2 other hives in a nature reserve the Alpes nearby, where no agro-chemicals are used. These hives are perfectly healthy and my bees even live throughout the cold winters without any problem.”

Appendix II

This interview was conducted with the President of the apiculture society of Lausanne, Switzerland, Mr. Roth. It has been translated from its original language – French.

Me: “Dear Mr. Roth, have you experienced any bee population decline these recent years?”

Mr. Roth: “Yes in fact I have, for the past 4 years I have been experiencing annually 30% losses of my colonies.”

Me: “Is this is a new phenomenon or have you always had this problem?”

Mr. Roth: “The severity of the collapses is definitely grater then previous years. But I have lost my entire colonies 3 times over 20 years, so bee decline is not in all a new issue.”

Me; “Do you know what could be causing these declines?”

Mr. Roth: “It’s always been due to the varroa mites. They destroy colonies all around Switzerland! I guess the miticides used against them are less effective then they use to be. Perhaps the parasite has developed some type of resistance to them.”

Me: “Do you think that insecticides/pesticides could also be causing the problem or at least aggravating it?”

Mr. Roth: “Absolutely not. Pesticides have nothing to do with the problem. All of my dead colonies were filled with varroa mites and I know that a new formula of miticides could solve the problem.”

Me: “Have you found all of the dead bees? Were they in the colony or was the colony empty?”

Mr. Roth: “The colonies had some dead bees in them, but not many. I guess they must have flown off somewhere to die. I just have not found them.”

Me: “Do you think that other factors could be weakening your bees immune system, preventing them from fighting the varroa mites?”

Mr. Roth: “I guess that environmental factor might be contributing to the problem, like toxins in the water and in the air. Perhaps temperature changes are also affecting them. But all in all, it is really the varroa mites that are problematic.”

Name:
Michel Roth
President of the beekeeper
association in the Region of Lake
Geneva
Contact Information:
Chemin Bornalet 2
1066 Épalinges
071 784 98 19

Appendix III

This interview was conducted with a French beekeeper that raises her bees next to Lake Lemman (aka Lake Geneva) to produce honey. During our interview she describe her and her husbands story with the honeybees.

Name:
Edith and Henry Talis
Beekeeper in the Region of the
Lemanic Alpes
Contact Information:
La Jonchère
74420 Boège
+33 4 50 39 17 64

“My father was a beekeeper, and in 1974, I took over the family business. I have always been around bees and until recently, I had never experience problem with their health. For the past 6 years, my husband and I have been experiencing severe colony losses, which has led us to replace 100 of our hives annually since 2007. We can no longer sustain these loses economically. We are now crippled with debt and most of our retirement money is gone; we will have to live with 500 euros a month for the rest of our life. We have been working all our adult lives with bees, and for what? We are giving up on the business because the bees can no longer survive sustainably. We are selling what is left of our honey stocks and that will be it.

I know what caused this and the worst part is that it going to kill many more bees then our own. We are surrounded by rapeseed farms in my area and coincidently, about 10 years ago, a new pesticides started to be used on most of them. Just a couple years later, the colonies began to collapse at an accelerated rate. It is no mystery. My father’s bees were healthy, and grandfather’s bees were healthy. The only thing that has changed in that time frame is not the parasites that have been present for many decades, but the chemicals used in the fields. They are designed to kill insect and pollinating beetles. How could they not affect the bees?”

“So you don’t believe that the varroa mites are central to the problem?”

“Not at all. As I said, these parasites have been around for a long time and collapses of this amplitude are very recent.”